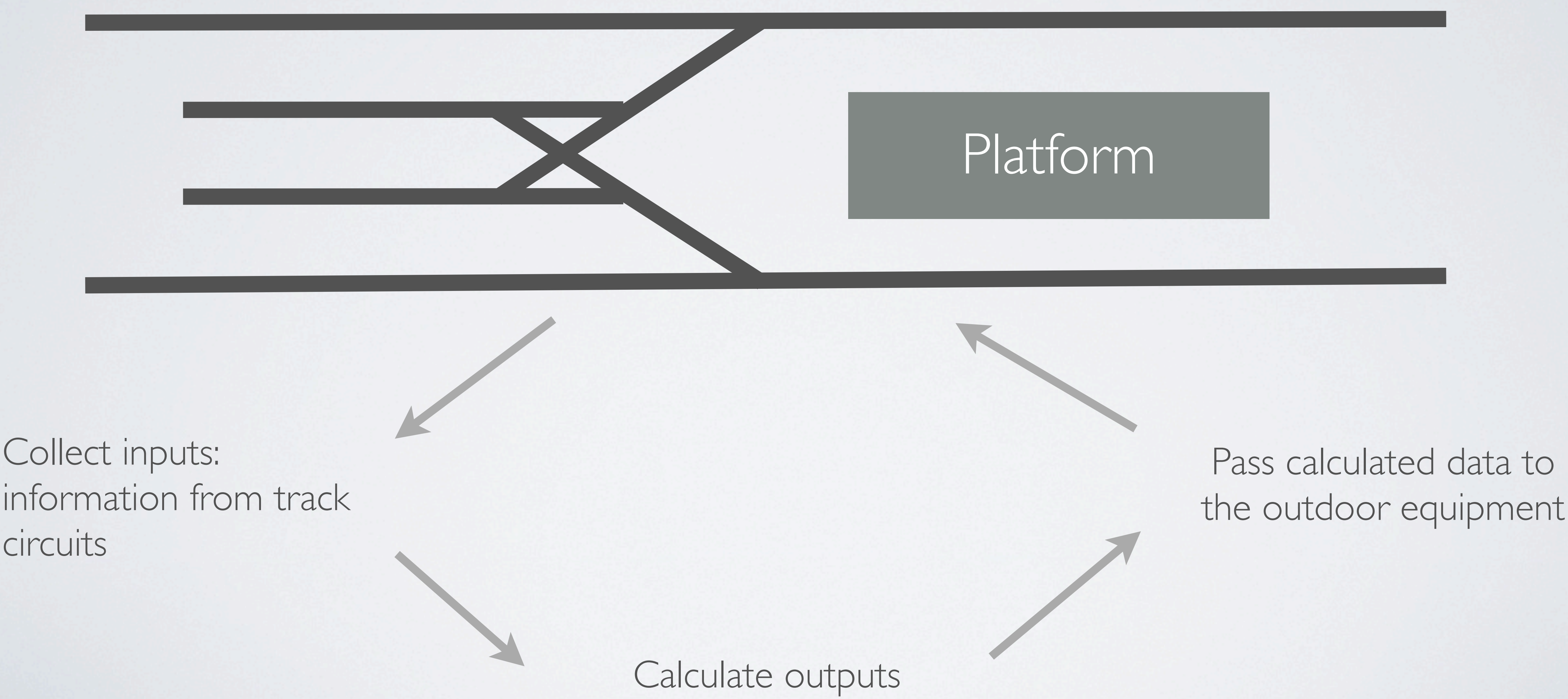
Linux Application in Safety-Critical Environment

Some Real-Life Examples

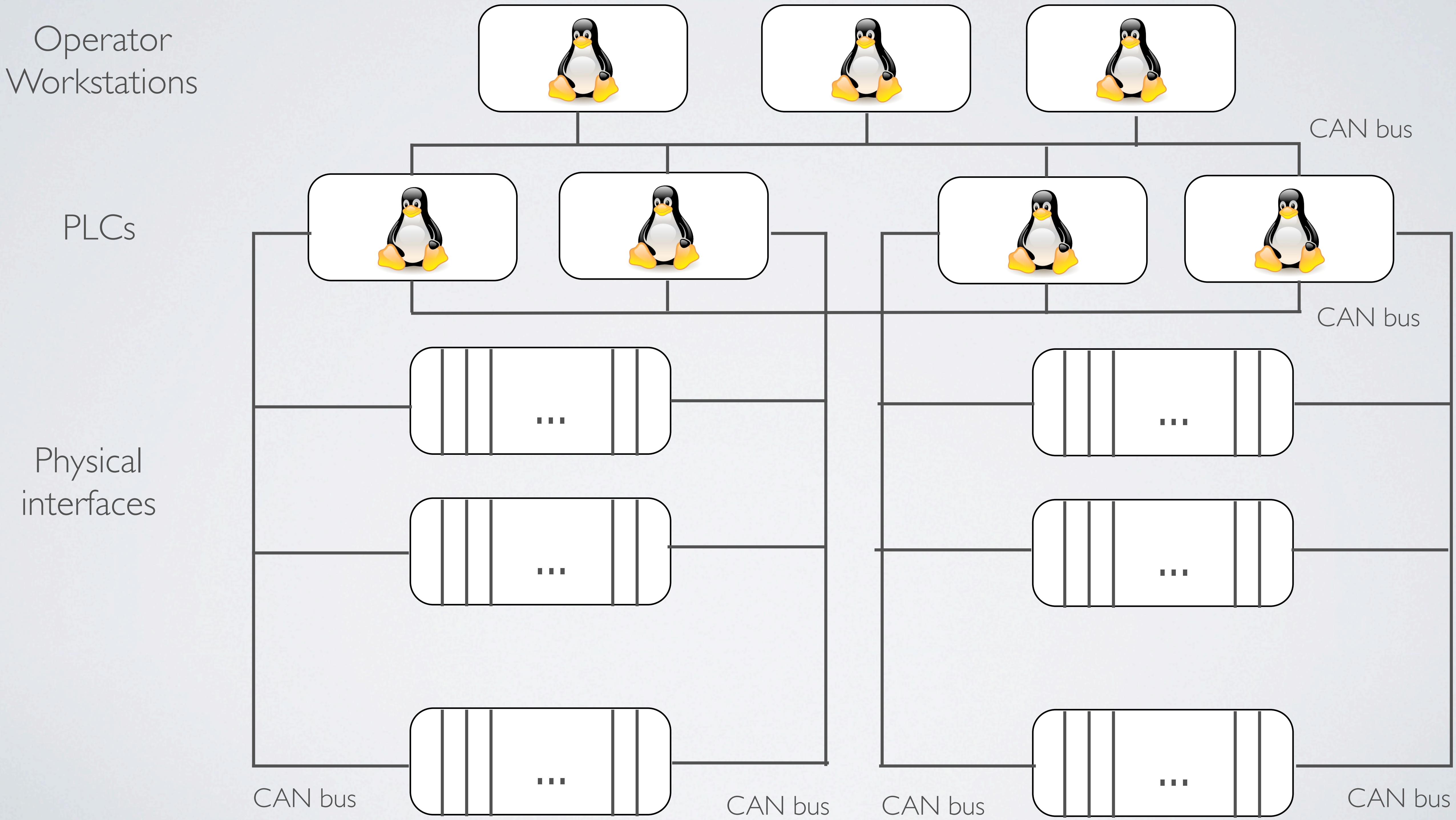
SAFETY

- General
  - IEC 61508
- For Railway Applications
  - EN 50126, EN 50128, EN 50129
- Failures Classification

Electric Interlocking System for Underground



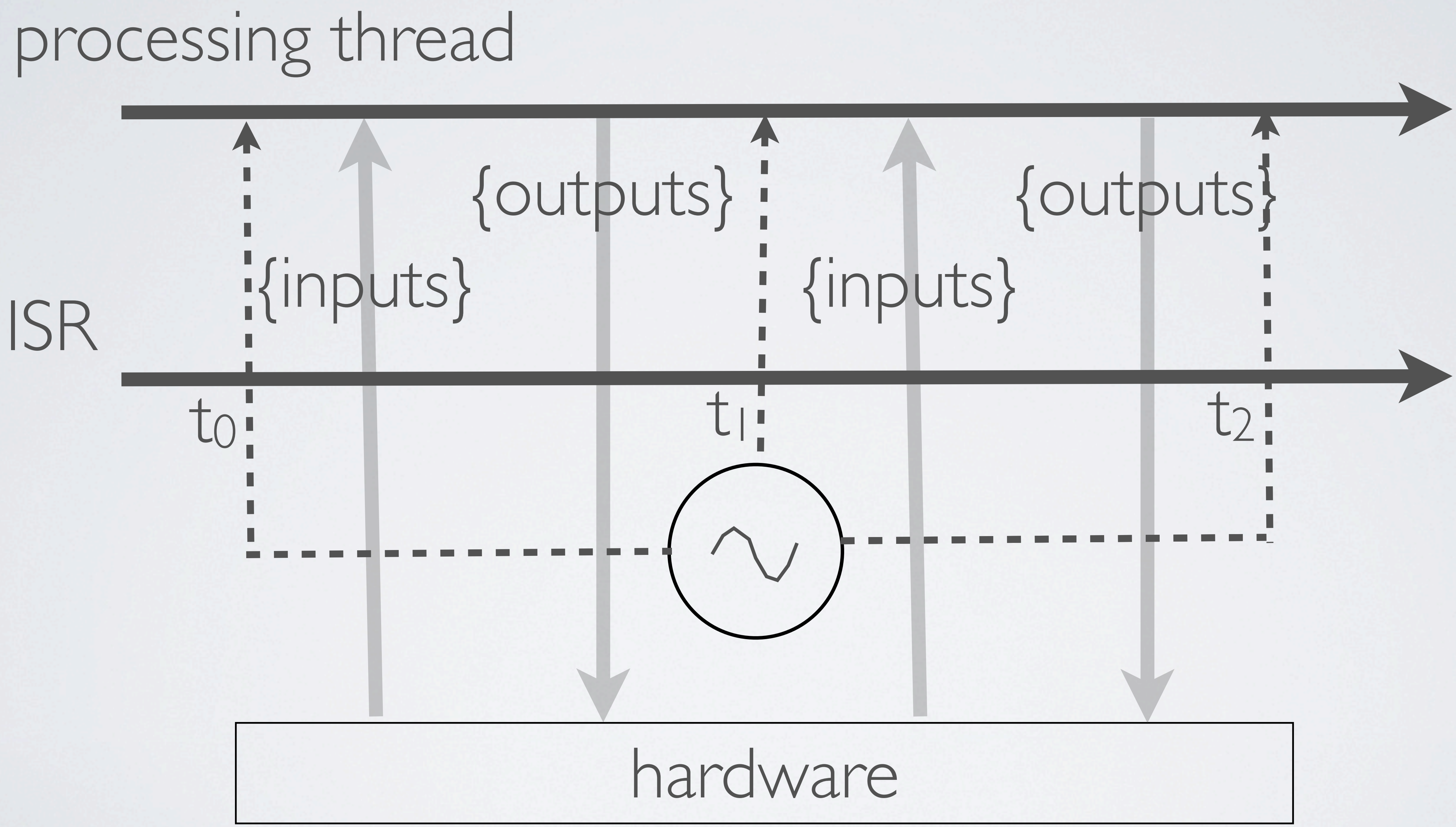
Electric Interlocking System for Underground



Concepts

- Fully synchronous design
- Safety-critical code isolation
- Keeping safety-critical code as simple as possible
- Software "safe states"
- Monitoring system health
- Redundancy
  - hardware
  - software

Concepts Synchronous Design



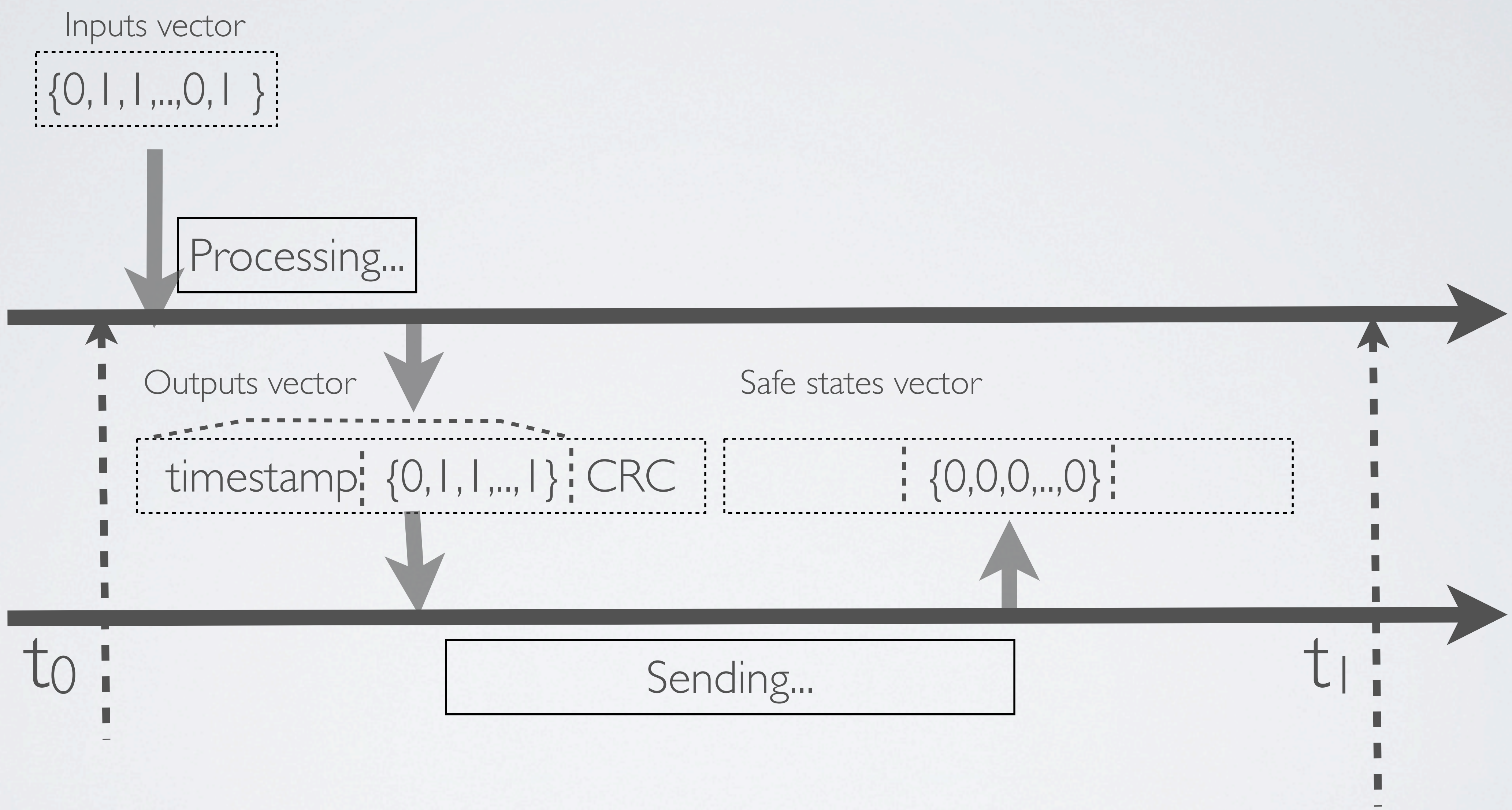
Real Time

- Guaranteed maximal response time
- Using interrupt threads to prioritize interrupts
- Carefully define priorities for
  - IRQ handler threads
  - realtime kernel threads
  - realtime userspace threads

Concepts Safety-critical code isolation

- Define which code is SC
- Specify inputs and outputs
- Prove code correctness
- Set required priority
- Monitor health

Concepts Safe States



Concepts Monitoring system health

- Monitor state of processes
  - alive status
  - memory consumption
  - scheduler statistics
- Generate alarms if something is going wrong
- Interchange health state between modules participating in hardware redundancy scheme

Concepts Hardware Redundancy

- Equipment is duplicated
- Outputs are cross checked
- Different boards with different CPU architectures are used
- Clock are synchronized

Concepts Software Redundancy

- Two different implementations for safety-critical process
  - written on different languages by different developers
  - the solution is only taken when they give equal results
  - alarm is raised otherwise and safe states are guaranteed on outputs
- Two different OS versions on modules

Building System

- Kernel
- Filesystems
- Startup
- Shutdown

Building System Kernel

- OSADL stable rt-linux recommendation:
  - 2.6.31.12-rt21 at the moment
- Standard tested configuration
- RT-Preempt Patch:
  - CONFIG_PREEMPT_RT=on
  - disable power management
  - disable high memory support
  - disable group CPU scheduler

Building System File System

- Read-Only root filesystem
- Separate filesystem for configuration data and logs

Building System Taking Off

- Configure system
  - remove the limit of CPU usage of RT processes
- Startup the child process
- Configure priorities
- Wait for its completion
  - monitor health
  - feed watchdog
- Simplified

```
#include <sys/wait.h>
#include <stdio.h>
#include <unistd.h>
#include <stdlib.h>

int main(int argc, char** argv)
{
pid_t safety_critical_process, appstatus;
int status;

/* System setup is going here*/
/* ... */

while(1) {
        safety_critical_process = fork();
        if ( safety_critical_process == -1 )
                exit(EXIT_FAILURE);

        if ( safety_critical_process == 0 ) {
                while (1) {
                        /* Health monitoring actions here */
                        sleep(INIT_QUANTUM);
                }
        }
        else {
                appstatus = waitpid(safety_critical_process, &status, 0);
                printf("exited: status %d\n restarting", status);
        }
}

}
```

Building System Landing

- Graceful shutdown
  - explicitly tell neighbors that we are not operational anymore
  - make log record

What’s now

- We must be ready to use Linux when it will be possible to certify it for SIL3/4 systems
- Until then we are using it in proof of concept designs taking special care of its possible misbehavior:
  - avoid hazardous failures falling back to safe states aggressively
  - use additional modules to provide hardware redundancy and special system design to minimize non-hazardous failures